

Richard W. Hamming



Learning to Learn

The Art of Doing Science and Engineering

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Session 21: Fiber Optics



Hamming's Five Questions

How to approach a new technology:

- What to look for ?
- What to watch for ?
- What to ignore ?
- What to keep abreast of ?
- What to ponder ?

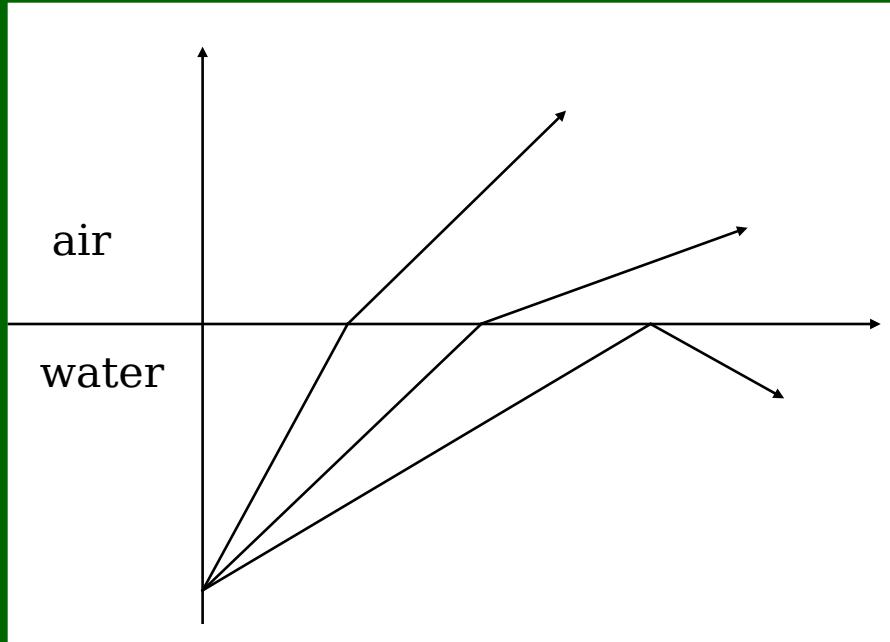
Every new field which arises in your future will present you similar questions, and you will effectively answer by your later actions.

The Importance of Fiber Optics



- Optical frequencies were very much higher than the electrical ones
- Fiber optics would have much greater bandwidth, and bandwidth is the effective rate of transmission
- Alexander Graham Bell had once sent a telephone conversation over a light beam .. so it can be done.
- There is an internal reflection as you go from a higher index medium to a lower index medium.

The Importance of Fiber Optics



Hamming wrote: “I understood in a fair way, what an optical fiber would be - they were a novel idea then.”



What I Looked for

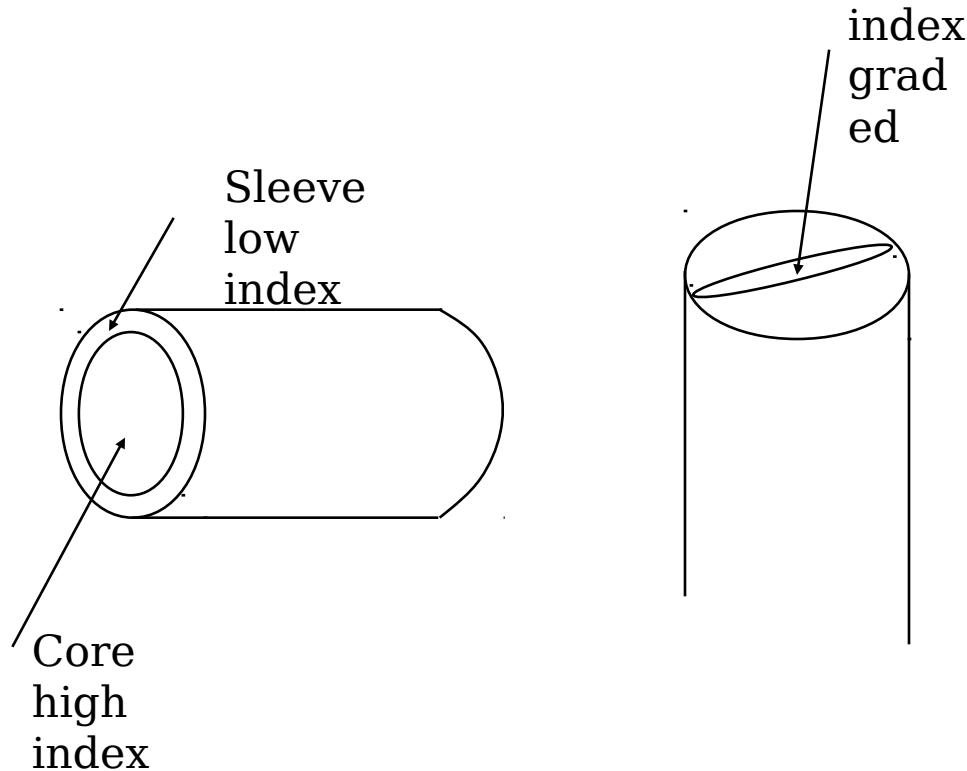
Hamming realized that fiber optics are resistant to electromagnetic disturbance (exp):

- Atomic explosion in the upper atmosphere
- Explosion In battle field
- Lightning strikes

He anticipated the fact that the outer sheathing put on the fiber might alter the local index of refraction ratios and let some of the light escape.

- putting a lower index glass sleeve around the higher index core
- Much later, a smoothly graded change in index of refraction was adopted

Conserving the Index of Refraction



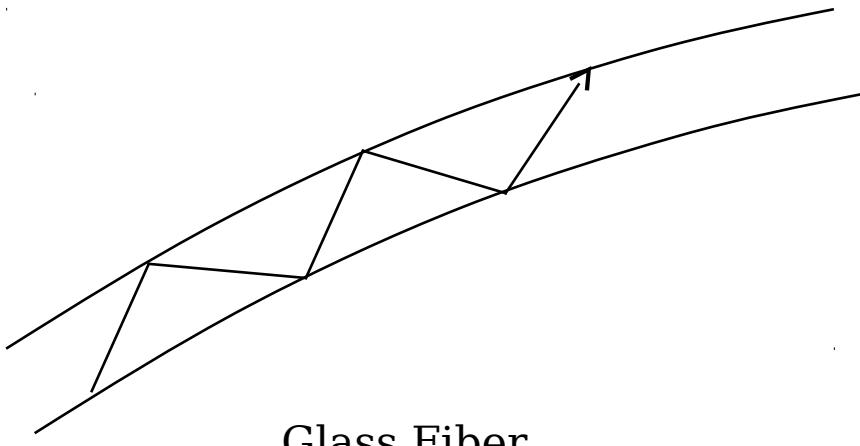


What I watched for

- The thinner the diameter, the more the fiber can bend without the light get out.
- A smaller diameter fiber will clearly have less distortion in the signal when going a given distance.

How did they propose to splice these fine, hair-sized glass fibers and still have good transmission?

Reflection Inside Glass Fiber



Glass Fiber



What I Ignored

multi-mode vs. the single-mode

I sort of backed the single mode on the same grounds that we had backed the binary against any higher base number systems in computer.



What I Kept Abreast of

What could be done when routing for telephone wire in a city like Manhattan begins running out of space?

If we use glass fibers with their smaller diameters then we can pull out the copper wires and put the glass fibers in their place.

This implies that Labs would have to do everything they could to develop glass fibers rapidly, and that it was going to be an ongoing source of computation problems.

“I had better keep myself abreast of development”



What I Pondered

Along the path of an optical wave:

- 1) Detecting the optical signal
- 2) Converting to electronic form
- 3) Amplifying it
- 4) Converting it back to optical form

Hamming said “it is hard to imagine a worse system design” and concluded that Labs, and many others, would have to work intensively on optical amplification.



Where We Are Now

Fiber-optic cables are sufficiently armored that trucks can run over them safely.

Fiber-lighted missiles are fired with an unreeling fiber attached throughout the flight - and this means two-way communications:

- *Direct the missile to the target*
- *Get back what the missile can see as it flies*

In the Navy, as well as in the obvious Air force and commercial aviation applications, the decreased weight means great savings which can be used for other things.

- *Use of fibers to replace all information-handling wires.*



Where We Are Now

Transoceanic cables with fiber instead of coaxial wave guides:

- *less cost*
- *More bandwidth*

Which is better: soliton signaling system or the classical pulse system of communicating across Pacific Ocean?

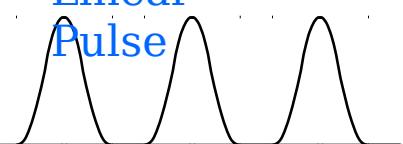
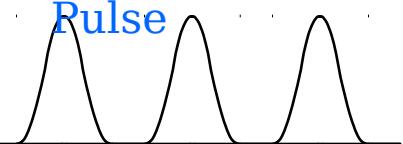
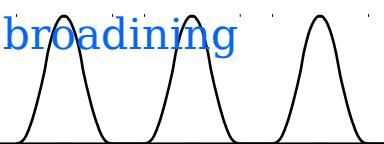
Hamming believes that in long run, solitons will be the dominant method, not pulses.

If transmission via solitons wins out over pulses, you had best keep abreast of it.



Solitons vs. Pulses

Solitons are pulses that keep their shape over long distances.

Input	Output	Characteristic
<p>Linear Pulse</p> 	<p>Pulse broadening due to dispersion</p> 	<p>Electrical Regeneration every 400-500 Km</p>
<p>Soliton Pulse</p> 	<p>No Pulse broadening</p> 	<p>More than 5000 Km without Electrical Regeneration.</p>



Fibers and Computer

How fiber optics could and would impact the design of computer

We now (1993) often interconnect the large units of a computer with fiber optics.

It is a matter of time before major parts of internal wiring will go optical

What about making a mother board in which integrated circuit chips are interconnected using fiber optics?



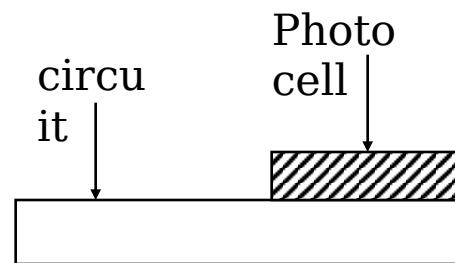
Fibers and Computer

What about making a mother board in which integrated circuit chips are interconnected using fiber optics?

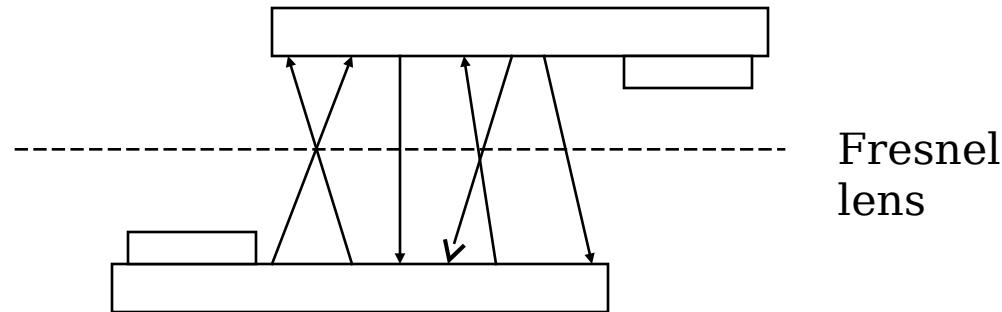
Can we not in time make optical chips, and have a general light source falling on a photocell on the chip to power it and avoid all the wiring of power distribution?

Can we replace chip wiring with light beam?

Powering the Chip



Fiber Chips Interconnection





Fibers and Computer

At first memory was the expensive part of computers, but with magnetic cores.

Now with electronic storage at fantastically cheap prices, the design and use of computer has significantly changed.

Can crossbar switches be made to be optical and not electronic?

- *Drop in computer cost*
- *How this will affect the computer design?*
- *Would the Von Neumann basic design survive at all?*



Anticipation

Your anticipation means you are far, far better prepared to absorb the new things when they arise than if you sit passively by and merely follow progress.

- “luck favors the prepared mind”
- Keep abreast of new technologies, or else you, like so many other people, will be left behind



Anticipation

Try to anticipate and be prepared for rapid changes in technologies.

You cannot lead everywhere in this highly technological society, but you need not be left behind by every new development.

There is no better way to be a significant contributor to your society than establishing in you the habit of anticipating things and leading rather than passively following.

Prediction of the Immediate future



It is fairly clear in time “drop lines” from the street to the house will be fiber optics.

- Once a fiber optic is installed then potentially you have available almost the information you could possibly want.
 - *TV, radio, and newspaper articles selected according to your interest profile.*
- There would be no need for separate information channels.
 - *Any channel, TV, radio, or phone, can be selected by you much as you do now.*
 - *A single time sharing filter would be available*



Will this happen ?

It is necessary to examine political, economic, and social conditions before saying what is technologically possible will in fact happen.

For example: is it advisable to have so much information distribution in the hands of a single company?

Do we as a society want it to happen?



What is technologically feasible?

A technological solution, even if it is economically superior, is restrained by legal, social, and economic conditions.

Just because it can be done economically does not mean it should be done.

If you do not get a firm grasp on these aspects, you will make a lot of false predictions